~~Jacob~~, Rebecca (GCI) AGL 341872

From: STIC-ILL
Sent: Tuesday, April 17, 2001 12:07 PM
To: Jacob, Rebecca (GCI)
Subject: FW: ill order

-----Original Message-----
From: Mellerson, Kendra
Sent: Tuesday, April 17, 2001 12:04 PM
To: STIC-ILL
Subject: FW: ill order

4/19, Caf

-----Original Message-----
From: **Sherrer, Curtis**
Sent: Monday, April 16, 2001 2:02 PM
To: STIC-EIC1700
Subject: ill order

Could I please get a copy of Bremner, T.S., J. Inst. Brewing, 69, pages 406+, 1969, i do not know the title or how many pages the article is. Thank you
Curt Sherrer
AU 1761
308-3847
CCP3 5EO4

Inert gas in wart kettle

EFFECT OF BOILING ON THE COLOUR OF LABORATORY MALT WORTS

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Received 6*th May*, 1963

Investigation of the effect of boiling on malt worts obtained in routine analysis using the Recommended Methods of the Institute of Brewing has indicated that an increase in colour of 50% may normally be expected. The presence of excess air up to a certain level will produce an increase in colour of some 75%, but air above this level has no further effect. If air can be excluded from the boiling wort the increase in colour can be diminished. Most of the colour increase takes place during the first hour of boiling. A broad relation appears to exist between the formation of colour and the permanently soluble nitrogen fraction; the ratio of permanently soluble to total soluble nitrogen is highest when the boiling takes place in excess air and lowest when air is excluded during the actual boil. Heating wort at 150° F. has the same effect on colour as boiling; subsequent boiling of heated wort can produce higher colours than boiling alone. The proportionate increase in colour is not influenced by either the original colour or the specific gravity of the wort. It is concluded that the malt has little or no influence in determining colour increase, but that variations in the mashing process and in the handling of wort in the under-back, copper, hop-back and wort receiver are responsible for the wide range of colours which may be observed in beers made from the same malt.

Introduction

In practice, there appears to be little or no relationship between the colour of malt, as determined by standard analytical procedure, and the colour of beer produced from the malt. Hence, whilst the malt colour may be of some significance in the assessment of how the malt has been made, it is of no practical value to the brewer in predicting the colour of his beer.

Kolbach & Schilfarth[2] attempted to relate tint increases to the curing temperature of the malt, but concluded that colour increase during boiling was practically independent of curing temperature. Siegfried,[3] using ten pale ale malts from different sources, also arrived at the conclusion that no direct connection exists between malt colour and beer colour.

Experimental and Discussion

Conditions of working.—The object of this investigation was to determine what effect heating had on the colour of malt worts obtained in routine analyses. Conditions of heating were standardized so far as possible as follows: A quantity of wort (200 ml.) was put in a 500-ml. kjeldahl flask with a long neck; the flask was supported on an asbestos pad in which a 2½-in. diam. hole had been cut and countersunk. A vertical reflux condenser was fitted to the top of the flask, and heating was by means of a bunsen flame. The surface of the liquid was 1½ in. above the surface of the asbestos, so that direct heating of only the base of the flask was possible. At the end of the boiling period heating was discontinued, and the flask was allowed to cool for 10–15 min. to minimize loss of water by evaporation. The condenser was then removed, and the contents of the flask were rapidly cooled to room temperature and filtered; the colour was read as soon thereafter as was convenient.

As a preliminary experiment, a quantity (200 ml.) of a 10% sucrose solution was boiled in the apparatus for 2 hr.; it was then cooled down to room temperature and, later, with the condenser removed, was re-boiled until the original volume was reduced to less than half. At the end of this treatment the solution was still completely colourless; the possibility of charring was accordingly virtually ruled out.

Then, during the course of 8 weeks, 87 different malt worts were subjected to a 2-hr. "standardized" boil, and the colours of the worts before and after boiling were recorded. The barleys from which the malts were made included numerous Scotch, Yorkshire, Norfolk, Lincolnshire and Australian Cape types; the malts themselves covered a comprehensive range, from distilling through pale to mild ales, comprising under-modified, highly modified, gibberellic acid-treated and laboratory experimental malts, in addition to normal floor and *Saladin* malts.

TABLE I

INCREASE IN WORT COLOUR WITH BOILING: FREQUENCY OF OCCURRENCE OF PARTICULAR INCREASES

(2-hr. boiling period)

Original colour (° E.B.C.)	No. of times these colours were read from units of original colour shown on left:																			
	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13	14	15	16
2	1		1																			
2½				1																		
3						3	3															
3½					2	2	5	2														
4							1	5	4													
4½							3	4	2	1	4											
5								1	1		1	2	1	3								
5½												2	4	2	1							
6												3		2	1	4						
6½												1		1	1	1						
7																		1				
7½															1	1		2				
8																1						
8½																	1					
9																					1	
9½																						1

In all cases, filtration of the boiled wort was rapid and the filtrate brilliant. Colours were read in a 25-mm. cell on the E.B.C. scale in a white-light cabinet; colours up to 10 were taken to the nearest ½ unit and over 10 to the nearest whole unit. No correction for the very small reduction in volume of the original volume was considered necessary. The sum totals (from Table I) of the 87 colours read were:

before boiling	..	415·5
after boiling	..	633·0
% increase	..	52·3;

however, the individual increases ranged from 20% to 80%, but it is suggested that this apparently wide range is in fact not a real one, and that it is likely on the following basis that a 50% increase is a reasonable assessment.

The method of reading colours does not give 100% accuracy, the colour being recorded to the nearest ½ degree. Further, it is possible for a different colour to be given to the same sample, even by the same operator after a short interval, so that the original colour is not necessarily represented by C but is, in fact, more probably within the range $C \pm x$, where x represents a difference in colour which cannot be assessed visually with any degree of accuracy. In an earlier Report, the writer[1] reproduced a Table showing differences in colour readings between operators which gave an average mean difference of 0·344 degrees on 82 colour readings. Assuming this figure to be one which might reasonably be expected to apply to visual reading of colour, then the original colour would be expected to lie within the range $C \pm 0{\cdot}344$ degrees. If this is so, a 50% increase in colour would produce a colour given by $C^1 = 1{\cdot}5\ (C \pm 0{\cdot}344)$, *i.e.*, $C^1 = 1{\cdot}5\ C \pm 0{\cdot}521$. Since, however, the increased colour would be subject to the same degree of accuracy in reading, it would not necessarily be in the range $1{\cdot}5C \pm 0{\cdot}521$, but rather in the range $1{\cdot}5C \pm 0{\cdot}521 \pm 0{\cdot}344$, *i.e.*, $1{\cdot}5C \pm 0{\cdot}865$. Accordingly, a difference in colour of nearly 1 degree between the final colour and 1·5 times the original colour might be an apparent difference only, and not necessarily a real one.

On averaging out the differences found between the colour after boiling and 1·5 times the original colour of all the samples tested, the mean difference for the whole series is 0·7 degrees.

The results are shown graphically in Fig. 1, using for convenience slightly different

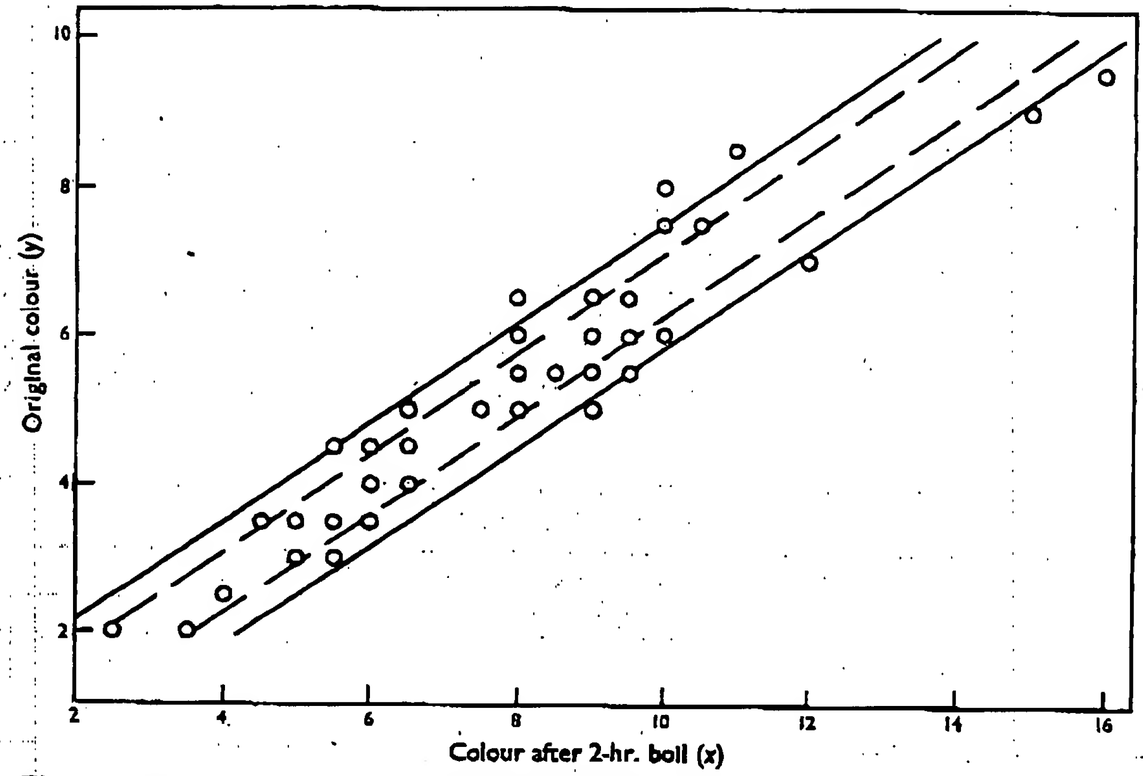

Fig. 1.—Relation between original colour (y) and colour (x) after boiling for 2 hr. The broken lines show the limits of $x = 1{\cdot}5\,(y \pm \frac{1}{4}) \pm \frac{1}{4}$, and the full lines the limits of $x = 1{\cdot}5\,(y \pm \frac{1}{2}) \pm \frac{1}{2}$.

arbitrary ranges, and it can be seen that the vast majority of colour increases lie within the calculated ranges, as shown by the solid lines which, of necessity, are parallel. If, however, the arbitrary range when a high colour is read is greater than for a low colour, then the lines will diverge from each other in an upwards direction, in which case nearly all the results fall within the calculated range.

Influence of volume and gravity.—As a further test, 50-ml., 100-ml. and 200-ml. quantities of the same malt wort were boiled simultaneously, in the prescribed manner, and the resulting colours were found to be identical. Also, 200 g. of ground malt were mashed with 600 ml. of water to produce an extract of S.G. 1087·5. A quantity (200 ml.) of this extract (colour 5) was boiled for 2 hr. and gave a final colour of 7½, so indicating

TABLE II

EFFECT OF BOILING ON MALT WORT

	Original colour	Colour after boiling for (hr.):						P.S.N./T.S.N. after boiling for (hr.):					
		½	1	1½	2	2½	3	½	1	1½	2	2½	3
	3½ 4 4½	4½ 5 4½	5 5½ 5½	5 5½ 5½	5½ 5½ 5½	6½ 6½ 6	6 6 6	95·5	93·3	91·0	91·0	91·0	89·9
	3½ 3½ 4	4 4½ 4½	5 5 5	5 5 5	5½ 5½ 5½	6 5½ 6	5½ 5½ 6	96·8	94·6	93·6	93·6	91·4	90·3
	4 4 4	4½ 4½ 4½	— — —	5½ 5 5½	6 5½ 5½	6 6½ 6	6½ 6 6	94·4	—	93·3	92·2	91·1	90·0
	4 4	4½ 4½	5½ 5½	5½ 5½	5½ 6	6 6	5½ 6	95·7	93·5	91·3	92·4	90·2	88·0
Means	3·91	4·86	5·25	5·27	5·59	6·09	5·91	95·6	93·8	92·3	92·3	90·9	89·6
Calculated*	—	4·77	5·14	5·41	5·41	5·68	4·95						

* Calculation from formula C′ = C × (6 − 5 P.S.N./T.S.N.).

that colour increase is independent of either the volume boiled or the specific gravity of the wort.

Boiling for varying periods.—A quantity of wort was prepared from standard mashes and, after reading the colour, 200-ml. portions were put into kjeldahl flasks and boiled individually under reflux for ½, 1, 1½, 2, 2½ or 3 hr. At the end of each boiling period the contents of the flask concerned were cooled and filtered as before and the colour read, this time by two or more operators acting independently; all results were recorded (Table II). Most of the colour increase took place in the first hour, but further colour appeared to develop up to 2½–3 hr.

Boiling under varying conditions.—200-ml. portions of the same wort were boiled under reflux: (*a*) in the normal way as before; (*b*) with air bubbling through the boiling wort continuously during the boil; and (*c*) under an atmosphere of CO_2.

In the case of *b*, air was injected in a stream of fine bubbles on to the bottom of the flask in order to give intimate mixing with the boiling wort, and the total volume of air which had passed through the wort was measured roughly and expressed as ml. air per ml. wort. The rate of flow in the course of the experiments ranged from 10 ml. to 100 ml. air per ml. wort.

As before the original colours and resulting colours were read independently by two or more operators, and all results were recorded (Table III).

Of 16 worts tested, once more it was established that under "normal" boiling conditions the colour increase averaged 50%. With excess of air, however, the increase was greater, and amounted to an average of 75%. At the same time, it was apparent that the greater increase took place in the presence of a quite small excess of air and was not in any way related to the rate of flow or the total volume of air used.

In the case of the worts boiled under CO_2, after the wort was introduced into the flask the air in the flask was expelled by passing a rapid burst of gas into the flask from a point some 2 in. above the surface of the wort. All through the boil, a steady stream of gas continued to pass into the flask in order to prevent air being brought down into the wort by condensate from the condenser. With this treatment, the average increase in colour was only slightly less than with the "normal" boil.

TABLE III

INFLUENCE OF AIR AND CARBON DIOXIDE ON COLOUR INCREASE

(Original colour range 3½–21. Totals of colours recorded were: original 274·5; normal boil 416; boil in air 492·5; boil in CO_2 393)

Air (ml.) per ml. wort	Increase in colour (%) after 2-hr. boil		
	Normal	Air	CO_2
10	38	77	38
20	54	87	56
25	42	54	38
25	39	75	36
30	37	76	29
35	41	64	36
40*	38	81	27
50	52	76	43
50	67	90	50
55	48	79	34
55	51	72	31
75	60	83	54
100**	57	83	50
Average increase	51	79	43

* 10-min. mash.
** Wort of 1060 specific gravity (colour 21).

A further point of interest was that, under the three sets of conditions just described, the colour increases of high gravity worts (1060°) were of the same order as those of normal worts, as were the colour increases obtained on worts prepared by stirring a 10% mash for 2 min. at 150° F. and cooling before filtering, a total time of about 10 min. The latter method is one normally used to determine rapidly the colour of a malt sample.

As a further experiment a number of wort filtrates (200 ml.) from standard mashes were allowed to stand in a mashing bath at 150° F. for 2 hr. This treatment produced a very hazy solution which resisted all attempts to filter bright, but it was apparent that not only had a substantial increase in colour taken place, but that the increase was as great as, if not greater than, that obtained in a "normal" 2-hr. boil.

Subsequently, worts which had been re-mashed in the foregoing way were boiled under reflux for 1½–2 hr. to coagulate the separated nitrogenous matter, and this enabled clear filtrates to be obtained. The

system was found to produce colour increases of from 75% to 125% over the original colour (Table IV).

TABLE IV

EFFECT ON COLOUR OF RE-MASHING FILTERED WORT AT 150° F. FOR 2 HR. WITHOUT AND WITH SUBSEQUENT BOILING

Original colour	Colour after re-mashing: not boiled	Colour after re-mashing: boiled	P.S.N./T.S.N. (%)
2	3½	4	—
	4	4½	—
	4	4½	—
2½	—	5½	93·8
	—	5½	—
	—	5½	—
4½	6	8	—
	7	8	—
	6	8	—
6	—	10½	92·0
	—	11	—
	—	10	—
6	9	11	—
	10	11½	—
	9½	11½	—

Finally the effect was investigated of stirring aliquots of the same wort: (*a*) magnetically in bright daylight in a flask open to the atmosphere; (*b*) at 150° F. with a stream of air bubbles; and (*c*) at 150° F. with a stream of CO_2 bubbles.

All samples were stirred for 2 hr., and in the case of *a* stirring was vigorous enough to produce a concentration of fine bubbles of air throughout the wort for the whole of the stirring time. Rather surprisingly, no increase in colour resulted from this treatment and the wort remained bright right to the end. Both *b* and *c*, although extremely difficult to filter, produced increases in colour of the same order, *viz.*, in the region of 60%.

Permanently soluble nitrogen.—In the early stages of the investigation it was observed that the physical appearance of the boiling worts differed on occasion. Usually the coagulum was carried upwards and deposited on the upper part of the bulb of the flask, leaving a bright boiling liquid at the base. Sometimes, however, the sediment remained in the boiling liquid in the form of a coagulated mass and sometimes as a fine suspension distributed throughout the bulk. Such differences had no effect on the colour increases which took place but, in view of them, it was decided to check the differences between the total soluble nitrogen and permanently soluble nitrogen of all the samples tested.

As a result it was found that, although the type of coagulation had apparently no effect on either the colour increase or the quantity precipitated, the P.S.N. figure averaged only 92·15% of the total soluble nitrogen, which is some 2% less than the average found by the old method[4] of determining P.S.N.

On comparing the P.S.N./T.S.N. ratios with the colour changes produced by boiling for different periods of time, there appeared to be a broad relationship between them. The formula used to calculate the resulting colour from the nitrogen fractions was:

$$\text{resulting colour} = \text{original colour} \times (6 - 5\ \text{P.S.N./T.S.N.}).$$

The relation between some observed and the corresponding calculated colour is shown in Fig. 2.

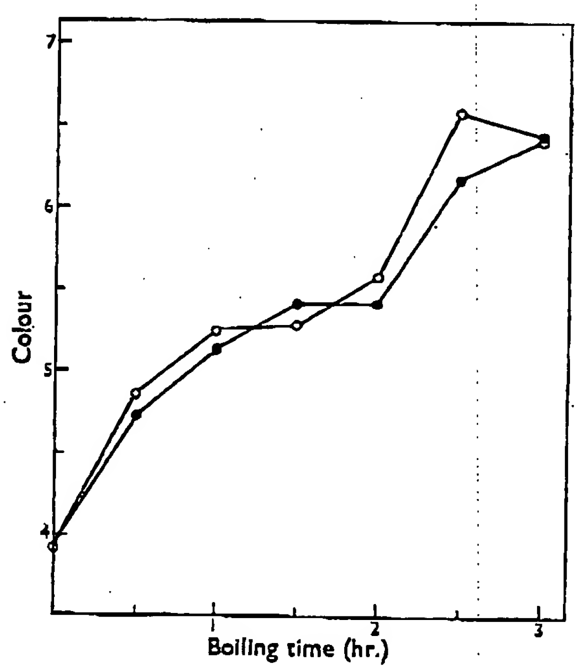

Fig. 2.—Colours observed (○) after boiling and colours calculated (●) from P.S.N./T.S.N. ratio (see Table II).

A point which may be of some significance also arose from the experiment on boiling worts under different conditions. Here it was found that the mean P.S.N./T.S.N. ratio

was lowest when the boil took place under CO_2 and was highest when in the presence of excess air (Table V). This would suggest that colour is formed in a reaction involving the coagulable nitrogen fraction with air, but until a lot more is known about the chemistry of melanoidin formation such a conclusion must remain purely hypothetical.

TABLE V

EFFECT ON PERMANENTLY SOLUBLE NITROGEN OF BOILING WORTS FOR 2 HR.

Wort no.	P.S.N./T.S.N. (%) Normal	In CO_2	In excess air
1	90·2	92·4	93·5
2	89·1	89·1	91·3
3	90·9	88·9	90·9
4	89·2	89·2	90·5
5	90·5	89·5	90·5
6*	93·5	92·5	94·4
7	92·6	91·7	92·6
8	90·6	89·6	91·7
9	89·9	89·9	90·9
10	90·7	89·7	90·7
11**	96·1	95·7	96·1
Averages	91·2	90·7	92·1

* High coloured wort.
** High gravity wort.

CONCLUSIONS

From the results obtained it would appear that, under standardized mashing and boiling conditions, the malt has no significant effect on colour increase. The presence of air, however, does influence the formation of colour, not only during boiling but also at lower temperatures such as may be found in the under-back. The degree of colour increase will depend on the amount of air present in the running wort and in the copper wort during the boil, up to a minimum figure which probably would have to be determined for every individual mash-tun and copper. Air in excess of this quantity would appear to be without effect.

It is possible that variations in mashing and boiling procedure and even the handling of the wort in the hop-back and wort receiver may also have some influence on colour formation; hence it must follow that, using the same malt, a wide range of beer colours can result.

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